

LEAD ASSESSMENT IN DOMESTIC WATER SOURCES IN KWARA STATE, NIGERIA

¹Mohammed S., ²Salami O.O & ¹Rafiu F.O

¹Department Geography and Remote Sensing, Faculty of Environmental Sciences, Kwara State University, Kwara State, Malete.

²Department of Environmental Management and Toxicology, Faculty of Pure and Applied Sciences, Kwara State University Malete.

Correspondence: Mohammed S,
Department of Geography and Planning, University of Jos, Nigeria.

E-mail: sanni.mohammed@kwasu.edu.ng

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Abstract

The rate of Water contamination by lead in sub-Saharan Africa is at an alarming rate, and it is a source of concern for the Environmental managers especially in Nigeria. Physiochemical parameters in water samples from tap water, well water, and river water in Malete were assessed. Water samples were collected over two weeks, and parameters such as turbidity, Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), pH, and lead (Pb) concentrations were measured using standard procedures. The results were then compared with World Health Organization (WHO) standards for drinking water. The major findings revealed that the Zinc and lead concentrations in Malete's water sources significantly exceeded WHO's permissible limits of 0.01 mg/L, with the highest lead levels detected in the Malete River (0.085 mg/L). Other physiochemical parameters, including TDS, COD, and BOD, indicated varying degrees of water quality issues, with particularly high organic pollution levels in the river water. These findings suggest that the water contamination originated from a combination of aging infrastructure, such as decayed lead pipes, and dumping of refuse. There is urgent need to take measures to curb this from escalating, youth occupy large space in to future generation, save guarding their health is key to national development. Replacing corroded lead pipes and alternative source of water will help reduce over dependent on one source of water.

Keywords: Lead, Water contamination, Kwara State Malete. Health of the Students

INTRODUCTION

The term “heavy metals” refers to any metallic element that has relatively high density and applies to the group of metals and metalloids with atomic density greater than 5 g cm⁻³ (Anyanwu & Nwachucku, 2020; Oves et al., 2012). Some of them are essential elements without which the biochemical processes in living organisms would not be possible; however, when they exceed normal concentrations, they become harmful to organisms (Anyanwu et al 2020; Goorzadi et al. 2009; Bytyçi et al. 2018). Anyanwu et al (2020) stated that heavy metals may contaminate the surface water, springs and groundwater resulting in deterioration of drinking water quality.

Liu et al (2022) concerning lead levels indicating persistent contamination issues in drinking water supplies, even after lead control policies aimed to restrict emissions (Liu et al., 2022). Investigations focused on water systems in northeast US cities identified distributions pointing to service line corrosion as the primary source of lead release rather than source water contamination or treatment breakthrough (Pieper et al., 2018). However, schools and homes with legacy lead piping remain at highest risk if corrosion inhibitors are not maintained (Clark et al., 2021). At schools, sampling water outlets like bubblers, fountains, and faucets helped screen a wider surface area for identifying problem zones (Spayd et al., 2022).

Lead (Pb), is a heavy metal that is widely distributed

in the environment from both natural and anthropogenic sources. Natural lead emissions result primarily from volcanic activity, forest fires, and weathering processes while key anthropogenic sources include mining operations, coal combustion, waste incineration, automobile exhaust, and various industrial processes (Bradl et al., 2022). Due to its widespread use throughout history in products like leaded gasoline and paint, anthropogenic activities have profoundly increased environmental lead levels (Song et al., 2021). Lead has no known biological function and is identified as one of the most systemic toxicants that can induce multiple organ damage even at low levels of exposure (Wang et al., 2022). Both acute and chronic lead exposure can result in severe health effects ranging from gastro intestinal issues to central nervous system and kidney disorders (Bernard, 2021). Developmental neuro toxicity is of particular concern, as lead exposure in pregnant mothers and young children causes significant cognitive deficits and intellectual disability (Kordas et al., 2022).

Recent work continues highlighting lead risks to various other physiological processes as well, including immune response, vision issues, cardiovascular impacts, cancer promotion, and reproduction system disruption (Wang et al., 2022). World health organization (WHO, 2021) estimates that 1.5 million deaths globally in 2021 were due to lead exposure primarily cardiovascular effects and can also affects various organ and systems including nervous, urinary and reproductive organs. According to Emmauel (2022) that lead (Pb) exposure is one of the generally acknowledged as one of the most widespread environmental health hazards in West Africa and there is heightened concerned over adverse effects at various levels of exposure at dose level once considered to be safe. Lead poisoning is a great public health concern in the Nigerian state of Zamfara due to widespread gold ore mining by artisan miners using rudimentary and unsafe processing techniques. Children aged ≤ 6 years are especially vulnerable to lead poisoning, which accounts for 0.6% of the global burden of disease (Kabitu, 2014). Ahmad et al (2021) said due to urbanization and industrialization, there has been an increase in solid waste generation and has become a global concern and leakage of leachate from landfills contaminate the soil and groundwater and hence can have a severe impact on human health. The present

study aimed to determine the composition of toxic metals (Cr, Mn, Cu, As) and heavy metals (Cd, Ba, Hg, Pb) in soil and water by an inductively coupled plasma optical emission spectrometer (ICP-OES).

Asebiode et al. (2021), centered on sustainability analysis of community based rural water supply initiatives in Kwara state, Nigeria Rural communities' economic growth relies heavily on the consistent and sustainable provision of water services, which enhances residents' quality of life and drives agricultural wealth generation. Unfortunately, there is a troubling trend of borehole schemes deteriorating, being abandoned, or underperforming after being transferred to these communities. This issue poses a serious obstacle to rural development and impedes progress toward Sustainable Development Goal six. Ben-Uwabor et al (2024), evaluate Seasonal Variations of Lead Concentration and Proximate Composition of *Amaranthus hybridus* Grown and Consumed in Ilorin, Kwara State, and Northern Nigeria. The result obtained reveal significant level of contamination of irrigation water and *Amaranthus hybridus* most values obtained were above the permissible limits, hence, the vegetable may constitute health hazard for the consumers. The study hence suggests that growing of the edible crops around locations that are Pb polluted should be discouraged.

Due to extensive research validating such severe multi-organ impacts, regulations have aimed to control industrial lead emissions and eliminate products utilizing lead additives. However, legacy contamination and continued lesser-known uses allow lead pollution to persist as an insidious public health threat (Trevezas et al., 2022). Lead released decades ago remains accessible to bio-uptake and human contact, while new uncontrolled pathways emerge from sectors like aviation, plastics additives, and expanding e-waste volumes (Kordas et al., 2022). Lead can enter drinking water supplies from a variety of sources, with the most prominent being lead service lines delivering water from municipal treatment plants to homes (Clark et al., 2021). Lead piping was commonly used until the 1980s before the risks were fully realized (Santos et al., 2021). Lead solder and pipe fitting used to join water pipes also remains a significant source, especially in older distribution systems (Gomez et al., 2022). Industrial waste containing lead discharged into natural water

bodies also accumulates in sediment, aquatic organisms, and eventually public water supplies abstracted for treatment (Siddique et al., 2021). Other contamination sources include imported foods, kitchenware and cosmetics contaminated with lead that eventually leach into waterways (Viviano and Salazar, 2022). Lead is a potent neurotoxin, and developing fetuses, infants, and young children are at highest risk from exposure because this disrupts brain and nervous system development, causing reduced IQ and cognitive deficits (Sprinkle, 2021). Studies have definitively linked early childhood lead absorption to impaired learning, memory, behavior control, and lowered educational attainment (Ngueta et al., 2022). Adverse cardiovascular effects, kidney dysfunction, reproductive issues, and cancer risks have also been associated with lead ingestion from drinking water by adults with chronic exposures (Abadin et al., 2022). This study aims to study the risks in the consumption of multiple lead to human health in Malete, Kwara State and in other parts of Nigeria as a country.

MATERIALS AND METHODS

Study Area

Malete is the present home of Kwara State University, the school in so many ways projected and had significant influence on the town and became the home of children from Ilorin and its surroundings, and from far and near. Malete located with latitude 8°41'59N and longitude 4°28'0E and found within Moro Local Government of the State has experienced significant growth in terms of development and infrastructure which has had an impact on the standard of living in the town. It was an agrarian society in the past largely occupied by Yoruba speaking people. The population of town has sprawl due to siting of this institution. Malete served by aging pipe distribution systems present an overlooked risk for lead exposure that warrants dedicated investigation. While lead contamination incidents in cities like Ilorin have captured national attention, rural schools, University and homes face similar vulnerabilities without the visibility or resources to address issues proactively. Lead leaching from pipes, joints, and fittings escalates when corrosion control measures fail, enabling contamination even where source water is from

unpolluted wells or reservoirs. This can impact the nearly all student and people in Malete community relying on potentially deteriorating small system water infrastructure. The study was carried out at some selected areas (Westend, Safari and School Road) in Malete, Moro Local Government, Kwara State University, Malete, Ilorin, Kwara State.

The research was carried out in Malete and stratified methods was used. The community was divided into geographical areas such as Westend, Safari and School Road to ensure representative sampling. Water sample source type such as well, borehole and river. Random Sampling method was used within the strata. Well, boreholes and river were randomly selected from each stratum to ensure representation. Determination of Acidity Test procedure is in accordance to IS: 3025 (Part 22) - Reaffirmed 2003. In addition to Indian Standard. The procedure stated in (1) APHA Standard Methods for the Examination of Water and Wastewater - 20th Edition. Method 2310. 17 (2) were highlighted.

Determination of pH, the pH was measured using a pH meter. The electrode was washed thoroughly first with distilled water and then with the sample. The pH meter was standardized using buffer solution. The pH of the samples was measured and the readings recorded. 3.4.3 Determination of Dissolved Oxygen (DO) The dissolved oxygen (DO) content of the stored water sample was measured using the Jenway Model 9070 water proof meter according to the standard method.

Determination of Biochemical Oxygen Demand (BOD) The BOD determination of the stored water tank samples was carried out using standard methods described by APHA (2022). Samples were incubated for five days at 20°C in BOD bottles. The dissolved oxygen (DO) content of the samples was determined before and after the incubation. BOD was calculated after the incubation period. $18 \text{ BOD}_5 = \text{Dissolved oxygen after incubation period (5 days)} - \text{Dissolved oxygen of the first Day}$. Determination of Chemical Oxygen Demand (COD) The COD of the stored water tanks samples were determined using the standard method described by APHA (2022). 3.4.6 Determination of Conductivity of the stored water tanks sample was determined using the standard procedure approved by APHA (2022). The conductivity meter (Hach model CO150) was used.

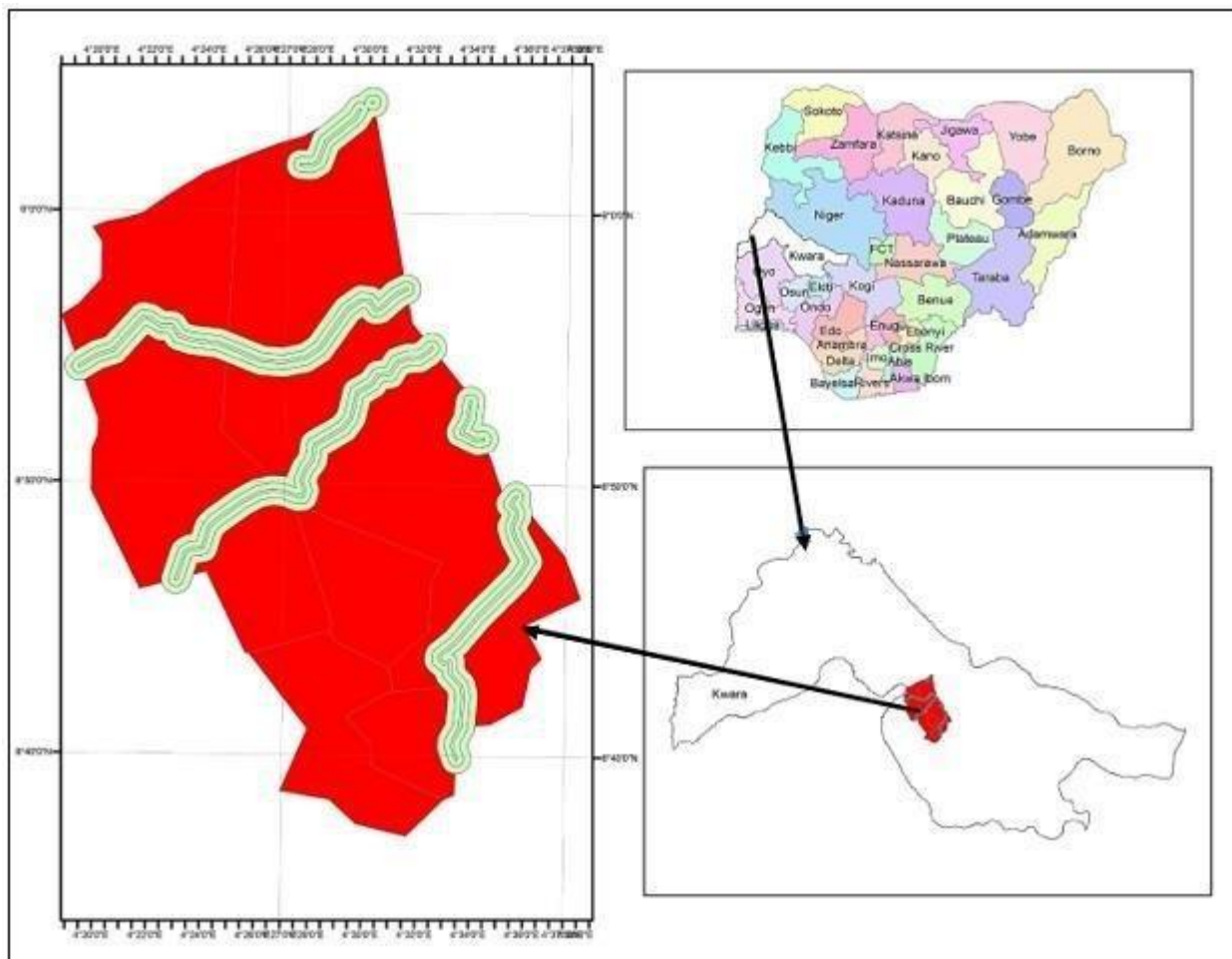


Figure 1: Study points in Malete, Malete in Kwara, Nigeria
Source: USGS Earth Explorer

The power key and the conductivity key of the conductivity meter switched on, and the temperature of the meter adjusted; the instrument calibrated with 0.001 MKCl to give a value of 14.7ms/m at 250C. The probe was dipped below the surface of both samples. Time was allowed for the reading to be stabilized and the reading was recorded.

Total Dissolved Solids, this is given as a number expressing the concentration of filterable solids present in water. Water with high concentration of dissolved solid present has poor taste and may induce unfavorable psychological reaction in the consumer. For this reason, a limit of 500mg/l of dissolved solids is desirable for potable waters. This includes settleable and non-settleable solids (APHA, 2022). Total Suspended Solids (TSS), these procedures will be used to obtain the suspended is as follows: a filter paper will be weighed and recorder before filtering

50 mls of the samples, the filter paper oven dried at 1000C. TSS will be calculated thus: $TSS (mg/l) = (final - initial \text{ weight}) \times (\text{amount of sample}) - 1 \times 1000$ (APHA, 2022)

Heavy metal concentration determination

The micro reaction tube was filled with 1ml of the water sample to be tested. A 5 µl internal standard (IS) solution (Ga, 100 mg/L, end concentration 500 µg/L) and added the sample were then homogenized. A sample of 10 µl homogenised solution pipetted on a siliconized sample carrier and dry heated at (60 °C) (Dike et al., 2004). All measurements were performed using the bench top TXRF spectrometer S2 PICOFOX (Stosnach, 2007). The following elements were quantified; Zn, and Pb. The results were expressed as micro grams per litre (µg/l). The analytical phase involved the analysis of mean heavy metal concentrations in water samples.

Samples of water was collected and analyzed to measure the impact of the Zinc and lead on water and the dilution effect. Water sample collection and preparation. Samples of water were collected from different points (Westend, Safari and School Road) in Malete. The samples collected from different pipe sources were then mixed together to produce a composite sample. From this a 500 ml representative samples were then collected in white plastic bottles according to standard procedures. The heavy metal data was analysed using Microsoft excel to obtain the

mean and standard error of the mean which was then subjected to statistical tests of significance using ANOVA ($p < 0.05$).

RESULTS AND DISCUSSION

The results of the water quality assessment for Malete tap water, well water, and river water were obtained through a series of physiochemical and atomic absorption spectrophotometer analyses over two consecutive weeks.

Table 1: World Health Organization Standard (WHO)

Turbidity (ppm)	TDS Mg/l	COD Mg/l	SALINITY Ppm	EC Mg/l	DO Mg/l	BOD Mg/l	Chloride Mg/l	TTS Mg/l	Ph mg/	LEAD	Zink
5NTU	500	10	500	1000	5	3	250	-	6.5	0.01	0.01

Source: WHO

The analysis focused on critical parameters such as turbidity, total dissolved solids (TDS), chemical oxygen demand (COD), salinity, electrical conductivity (EC), dissolved oxygen (DO), biochemical oxygen demand (BOD), chloride content, total suspended solids (TTS), pH, and

concentrations of zinc (Zn) and lead (Pb). The results provide insight into the overall quality of these water sources and their compliance with World Health Organization (WHO) standards for drinking water (Table 1).

Table2: Physiochemical analysis (week1)

S/N	Turbidity (ppm)	TDS (mg/l)	COD (mg/l)	Salinity (ppm)	EC (mg/l)	DO (mg/l)	BOD (mg/l)	chloride (mg/l)	TTS (mg/l)	Ph
A	00.9	165	15.228	164	332	3.2	3.025	10.064	4.8	7.25
B	11.7	207	12.321	205	414	4.1	2.217	4.367	3.2	6.83
C	02.2	314	29.524	313	633	10.1	6.114	8.542	14.6	7.29
D	4.93	228.67	19.02	227.33	459.67	5.80	3.79	7.66	7.53	7.12
E	5.78	78.92	9.08	78.28	153.27	3.62	1.99	2.88	5.75	0.25
F	5NTU	500	10	500	1000	5	3	250	-	6.5-8.5

Source: Author's Fieldwork

A= Malete tap water, B= Malete well. C=Malete river, D=Mean, E= Standard deviation F=WHO Standard

Table 2 presents the physiochemical analysis results for the first week of sampling from Malete tap water (Sample A), well water (Sample B), and river water (Sample C). The parameters measured include turbidity, TDS, COD, salinity, EC, DO, BOD, chloride, TTS, pH, and concentrations of Zn and Pb. The results are compared to WHO standards to evaluate the water quality and potential health risks. The results indicated that the river water (Sample C) exhibits significantly higher levels of turbidity, TDS, COD, salinity, EC, DO, BOD, chloride, and TTS

compared to the tap and well water. This suggested a higher degree of contamination in the river, likely due to run off and other pollutants. Notably, the Pb concentration in the river water (0.085mg/l) is substantially above the WHO standard of 0.01mg/l, indicating a severe risk of lead contamination. The Zn levels also exceed the standard in all samples, though the river water shows the lowest concentration (0.038 mg/l). The pH values across all samples are within the acceptable range, suggesting that the water is neither too acidic nor too alkaline.

Table 3: Physiochemical analysis (week2)

S/N	Turbidity (ppm)	TDS (mg/l)	COD (mg/l)	Salinity (ppm)	EC (mg/l)	DO (mg/l)	BOD (mg/l)	chloride (mg/l)	TTS (mg/l)	pH
A	0.10	165	15.218	165	332	3.2	3.09	10.102	4.7	7.24
B	11.6	206	12.221	204	414	4.3	2.217	4.355	3.2	6.82
C	02.1	312	29.514	314	631	10.2	6.110	8.501	14.8	7.28
D	4.60	227.67	18.32	227.67	459.00	5.90	3.81	7.65	7.57	7.11
E	5.38	78.91	9.05	78.45	153.24	3.63	1.99	2.89	5.78	0.24
F	5 NTU	500	10	500	1000	5	3	250	-	6.5-

Source: Author's Fieldwork

A= Malete tap water, B= Malete well. C=Malete river, D=Mean, E= Standard deviation F=WHO Standard

Table 3 provides the results of the physiochemical analysis conducted in the second week on the same water samples from Malete. The parameters analyzed are consistent with those in the first week, offering a comparative view of the water quality over time. The second week's results show similar trends to those observed in the first week, with the river water (Sample C) again displaying higher levels of most

parameters, including turbidity, TDS, COD, salinity, and TTS. The Pb concentration remains alarmingly high in the river water (0.085 mg/l), far exceeding the WHO standard. The tap and well water samples also continue to show elevated levels of Zn and Pb, albeit lower than the river water. The consistency in the results over the two weeks suggests persistent contamination issues, particularly in the river, that require immediate attention.

Table 4: Atomic absorption spectrophotometer

S/N	Sample Code	Zn		Pb	
		D	R	D	R
1	A	-	0.067	-	0.001,
2	B	-	0.049	-	0.011
3	C	-	0.038	-	0.085
	Mean		0.051		0.032
	Standard deviation		0.015		0.043
	F		0.01		0.01

Source: Author's Fieldwork

A= Malete tap water, B= Malete well water, C= Malete river, D= Dilution factor, E= Actual readings (mg/l), F =WHO standard

Table 4 summarizes the results obtained from the atomic absorption spectrophotometer analysis, focusing specifically on the concentrations of zinc (Zn) and lead (Pb) in the three water sources (Malete tap water, well water, and river water). The atomic absorption spectrophotometer analysis highlights significant concerns regarding the levels of lead in all three water samples. The river water (Sample C) has the highest Pb concentration at 0.085 mg/l represented with colour green, followed by the well water (Sample B) at 0.011 mg/l, and the tap water (Sample A) at 0.001 mg/l. All samples, particularly the river water, exceed the WHO recommended limit

of 0.01mg/l for lead, indicating a serious risk of lead contamination. Zinc levels were also above the WHO standard across all samples, with the tap water showing the highest concentration at 0.067 mg/l represented in blue colour. These findings underscore the need for immediate measures to reduce heavy metal contamination in these water sources to safeguard public health.

The results of this study indicated significant levels of lead contamination in the water sources of Malete, Moro LGA, Kwara State. When compared with the World Health Organization (WHO) guidelines, which stipulate a maximum permissible lead concentration of 0.01 mg/L in drinking water, the

levels detected in Malete's water sources far exceed this limit. For instance, the Malete River, which is a primary water source for the community, recorded a lead concentration of 0.085 mg/L, over eight times the WHO threshold. Similarly, lead levels in Malete well water (0.011 mg/L) and tap water (0.001 mg/L) also indicate varying degrees of contamination, with the well water slightly exceeding the WHO standard. This alarming level of contamination is consistent with findings from other studies conducted in Nigeria and similar developing regions. For example, Ogundele et al. (2015) reported lead concentrations in rural water sources that significantly surpassed WHO standards, attributing the contamination to the widespread use of lead containing materials in plumbing and the discharge of industrial waste bodies. The lead levels in Malete's water sources suggest similar contamination pathways, particularly from aging infrastructure and environmental pollution. The results of this study underscore the urgent need for intervention in Malete. The lead levels not only breach WHO standards but also mirror the contamination trends observed in other parts of Nigeria and sub-Saharan Africa, where infrastructure degradation and insufficient waste management practices exacerbate water quality issues. The findings also align with existing literature that identifies plumbing materials and industrial pollution as primary sources of lead contamination in water supplies (Adedokun et al., 2016; Nriagu et al. 2009).

The water quality in Malete poses serious health risks to the local population, particularly with respect to lead contamination. The comparison with WHO standards and existing literature reveals that the water sources are compromised by both anthropogenic activities and natural factors, necessitating immediate remedial actions. Further research should explore long-term solutions to ensure safe drinking water for the residents of Malete and similar communities. The investigation into water contamination of lead in Malete community, Moro LGA, Kwara State, has revealed significant concerns regarding the safety of the water sources available to the residents. The study analyzed water from three primary sources: tap water, well water, and river water. Given these findings, it is imperative to explore and implement alternative water sources for the community. Options such as improving the municipal water supply, rainwater harvesting,

drilling boreholes, and installing water treatment systems should be considered to provide residents with safe and reliable water. Additionally, addressing the root causes of contamination, particularly through infrastructure upgrades and environmental protection measures, will be essential in mitigating the long-term risk of lead exposure in Malete. This study underscores the need for urgent intervention to ensure that the water consumed by the residents of Malete is free from harmful contaminants, particularly Zinc and lead. Protecting public health in this community will require coordinated efforts to improve water quality and provide safe, sustainable alternatives for water supply.

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